

WE CLAIM:

1. A method of forming an aqueous web comprising:

supplying to a headbox an aqueous stream comprising a major proportion of refined long fiber having an average weight-weighted fiber length of from at least about 2 mm to about 3.5 mm, and a minor portion of a second fiber selected from the group consisting of hardwood fibers, recycle fibers, secondary fibers, nonwoody fibers, eucalyptus fibers, high yield fibers, thermally curled fibers, thermally cross-linked bulking fibers, and mixtures thereof;

supplying to said aqueous stream a cationic wet strength agent selected from the group consisting of polyamide-epihalohydrin resins, thermosetting polyacrylamide resins, urea-formaldehyde resins, melamine formaldehyde resins, and mixtures thereof in an amount of from about 15 to about 30 lbs/ton of total fiber in the furnish;

supplying to said aqueous stream an anionic strength agent selected from the group consisting of carboxymethyl celluloses, carboxymethyl guar gums, anionic starches, anionic guar gums, anionic polyacrylamides, and mixtures thereof;

measuring the total anionic charge carried by said aqueous stream;

controlling the amount of cationic wet strength agent and anionic strength agent so that the net charge of said aqueous stream in the headbox is maintained in the range of from less than about zero to about $-115 \text{ meq} \times 10^{-6}$ per 10 ml;

depositing said aqueous stream on a first moving foraminous support to form a web;

non-compactively dewatering the web deposited on the first moving foraminous support to a consistency in the range of from about 10% to about 30%;

transferring the web to a second moving foraminous support;

drying the web to a consistency of at most about 98%;

removing the web from the foraminous support.

2. The method of claim 1, wherein the cationic and anionic strength agents are controlled so that the net charge is from about $-50 \text{ meq} \times 10^{-6}$ per 10 ml, to less than about zero $\text{meq} \times 10^{-6}$ per 10 ml.

3. The method of claim 1, wherein the speed of said second moving foraminous support is at least about 2% less than the speed of the first moving foraminous support, thereby imparting a fabric crepe to said web of at least about 2%.

4. The method of claim 1, wherein said removing step comprises:
adhering said web to an internally heated drying cylinder.

5. The method of claim 4, wherein further comprising:
creping said web from said drying cylinder.

6. The method of claim 5, wherein said creping imparts a reel crepe to said web of at least about 2%.

7. The method of claim 5, further comprising:
embossing said web to a sufficient degree to reduce its tensile modulus of stiffness by 10%.

8. The method of claim 1, further comprising:
embossing said web to a sufficient degree to reduce its tensile modulus of stiffness by at least about 10%.

9. A product produced by the method of claim 1.

10. A product produced by the method of claim 3.

11. A product produced by the method of claim 4.

12. A product produced by the method of claim 6.

13. A product produced by the method of claim 7.

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14. A product produced by the method of claim 8.

15. A single ply towel produced by the method of claim 7, wherein the basis weight is 15 to 35 lb/rm; the geometric mean wet tensile strength is 500 to 2200 g/3 in; the absorbency is 125 to 400 g/m²; and the geometric mean tensile modulus of stiffness is 50 to 150 g/in-%.

16. A fibrous web comprising:

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a major portion of refined long fiber having an average weight-weighted fiber length of from at least about 2 mm to about 3.5 mm;

a minor portion of a fiber selected from the group consisting of hardwood fibers, recycle fibers, secondary fibers, nonwoody fibers, and eucalyptus fibers, high yield fibers, thermally curled fibers, thermally cross-linked bulking fibers, and mixtures thereof;

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a cationic wet strength agent selected from the group consisting of polyamide-epihalohydrin resins, thermosetting polyacrylamide resins, urea-formaldehyde resins, melamine formaldehyde resins, and mixtures thereof in an amount of from about 15 to about 30 lbs/ton;

an anionic strength agent selected from carboxymethyl celluloses, carboxymethyl guar gums, anionic starches, anionic guar gums, anionic polyacrylamides, and mixtures thereof;

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said web having a machine direction stretch of at least about 8%, a cross-direction wet strength of at least about 29 g/3 in/lb of basis weight, and a tensile modulus of stiffness less than about 150 g/in-%.

17. The web of claim 16, wherein said web is a single ply paper towel.

18. A single ply towel product having a basis weight from 15 to 35 lb/rm; a geometric mean wet tensile strength from 500 to 2200 g/3 in; an absorbency from 125 to 400 g/m²; and a tensile modulus of stiffness from 50 to 150 g/in-% made by a process comprising:

5 supply to a headbox an aqueous stream comprising a major proportion of refined long fiber having an average weight-weighted fiber length of from at least about 2 mm to about 3.5 mm, and a minor portion of a second fiber selected from the group consisting of hardwood fiber, recycle fiber, secondary fiber, nonwoody fibers, eucalyptus fibers, high yield fibers, thermally curled fibers, thermally cross-linked bulking fibers, and mixtures thereof;

supplying to said aqueous stream a cationic wet strength agent selected from the group consisting of polyamide-epihalohydrin resins, thermosetting polyacrylamide resins, urea-formaldehyde resins, melamine formaldehyde resins, and mixtures thereof in an amount of from about 15 to about 30 lbs/tons of the total fiber in the furnish;

15 supplying to said aqueous stream an anionic strength agent selected from the group consisting of carboxymethyl celluloses, carboxymethyl guar gums, anionic starches, anionic guar gums, anionic polyacrylamides, and mixtures thereof;

measuring the total anionic charge carried by the aqueous stream;

controlling the amount of cationic wet strength agent and anionic strength agent so that the net charge of the aqueous stream in the headbox is maintained in the range of from
20 less than about zero to about $-115 \text{ meq} \times 10^{-6} \text{ per } 10 \text{ ml}$;

depositing said aqueous stream on a first moving foraminous support to form a web;

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non-compactively dewatering said web deposited on said first moving foraminous support to a consistency in the range of from about 10% to about 30%;

transferring said web to a second moving foraminous support wherein the speed of said second moving foraminous support is at least about 2% less than the speed of the first moving foraminous support, thereby imparting a fabric crepe to said web of at least about 2%;

drying said web to a consistency of at least about 40%;

transferring said web to an internally heated drying cylinder;

removing said web from said internally heated drying cylinder by a creping step wherein said creping imparts a reel crepe to said web of at least about 2%;

embossing said web to a sufficient degree to reduce its tensile modulus of stiffness by at least 10%.

19. The method of claim 18, wherein said anionic strength agent is carboxymethyl cellulose (CMC) and said CMC is added at 0.5 to 8 lbs/ton of fiber.

20. A product produced by the method of claim 18, wherein the average fiber length of the furnish, net charge in the aqueous stream, fabric crepe, wet strength resin level, dry strength resin level, dry crepe level, and strength reduction in embossing are controlled such that the creped embossed single ply towel exhibits a geometric mean tensile modulus of stiffness of not more than about 110 g/in-%; a geometric mean wet tensile strength of at least about 700 g/3 in; and basis weight of at least about 15 lb/rm.

21. A product produced by the method of claim 18, wherein the average fiber length of the furnish, net charge in the aqueous stream, fabric crepe, wet strength resin level, dry strength resin level, dry crepe level, and strength reduction in embossing are controlled such that

the creped embossed single ply towel exhibits a geometric mean wet strength per unit basis weight of at least about 38 g/3 in./ (lb/rm); an absorbency per unit weight of at least about 3.0 g/g; and a basis weight of at least about 15 lb/rm.

22. A product produced by the method of claim 18, wherein the average fiber length of the furnish, net charge in the aqueous stream, fabric crepe, wet strength resin level, dry crepe level, and strength reduction in embossing are controlled such that the creped embossed single ply towel exhibits a geometric mean wet tensile strength of at least about 700 g/3 in and a sensory panel softness of at least about 0.4 sensory softness units.

23. A single ply towel product having a basis weight from 15 to 35 lb/rm; a geometric mean wet tensile strength from 500 to 2200 g/3"; an absorbency from 125 to 400 g/m²; and a tensile modulus of stiffness from 50 to 150 g/in-% made by a process comprising:

supplying to a headbox an aqueous stream comprising a major proportion of refined long fiber having an average weight-weighted fiber length of from at least about 2 mm to about 3.5 mm, and a minor portion of a second fiber selected from the group consisting of hardwood fibers, recycle fibers, secondary fibers, nonwoody fibers, eucalyptus fibers, high yield fibers, thermally curled fibers, thermally cross-linked bulking fibers, and mixtures thereof;

supplying to said aqueous stream a cationic wet strength agent selected from the group consisting of polyamide-epihalohydrin resins, thermosetting polyacrylamide resins, urea-formaldehyde resins, melamine formaldehyde resins, and mixtures thereof in an amount of from about 15 to about 30 lbs/ton of total fiber in the furnish;

supplying to said aqueous stream an anionic strength agent selected from the group consisting of carboxymethyl celluloses, carboxymethyl guar gums, anionic starches, anionic guar gums, anionic polyacrylamides, and mixtures thereof;

measuring the total anionic charge carried by the aqueous stream;

5 controlling the amount of cationic wet strength agent and anionic strength agent so that the net charge of the aqueous stream in the headbox is maintained in the range of from less than about zero to about $-115 \text{ meq} \times 10^{-6}$ per 10 ml;

depositing said aqueous stream on a first moving foraminous support to form a web;

non-compactively dewatering said web deposited on said first moving foraminous support to a consistency in the range of from about 10% to about 30%;

transferring said web to a second moving foraminous support;

drying said web to a consistency of at most about 98%;

removing said web from said foraminous support.

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